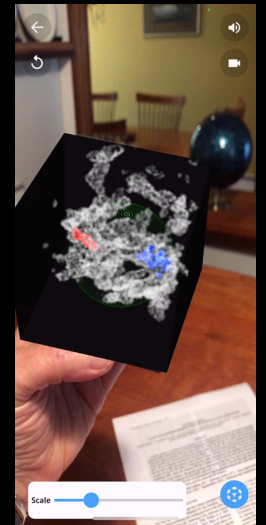
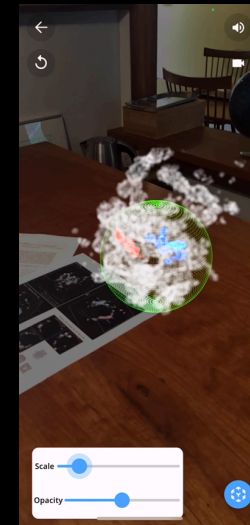
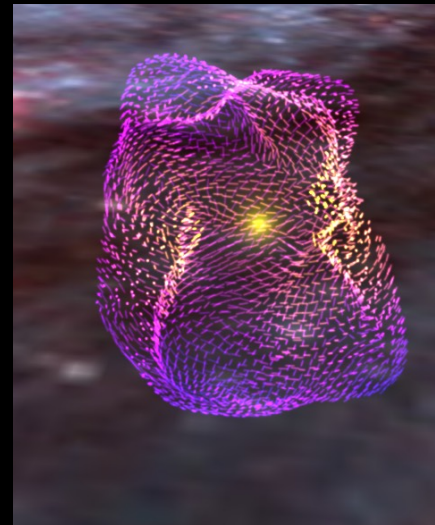


Do not worry about copying down links in this presentation—link to slides will be on Slack & Twitter “immediately.”

Exploratory Data Analysis and The Future, with glue

What is  **glue?**
multidimensional data exploration



Alyssa Goodman, Center for Astrophysics | Harvard & Smithsonian

What is glue?

multidimensional data exploration

It's not an acronym.

It is open-source software that
glues data,
glues graphs &
glues tools.

data



numbers (tables, arrays, spreadsheets)



images & maps (FITS, JPEG, GIS and more)



data cubes (3D, 4D, and more)

data files' common attributes are **glued**



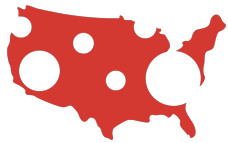
avoiding the need to merge data files

“graphs”



common statistical graphics

(scatterplots, histograms, tables, curves, overlays)



maps & images

(greyscale, color, contours, layer control...)



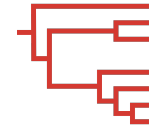
3D displays

(scatter plots, volumetric rendering, sliders...)



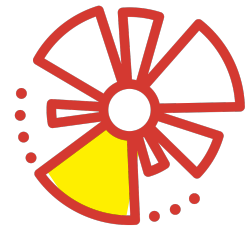
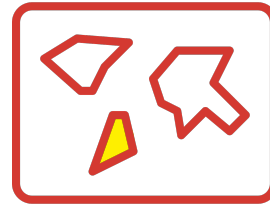
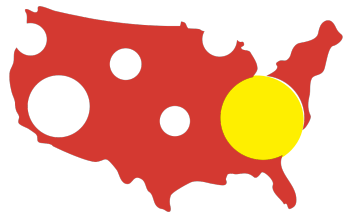
specialized & custom charts

(dendrograms, polar plots, + domain-specific options)





selections propagate across all **graphs**

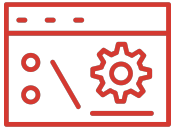


for real-time data exploration & insight

tools



plug-ins (user-defined formats, plots, layouts...)



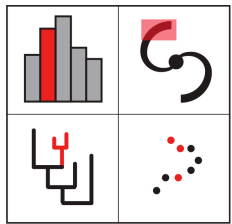
web services (across domains)



command-line (built-in terminal, scriptable)



for easy customization



glue
multidimensional data exploration

glues data,
glues graphs &
glues tools.

glueviz.org

BONUS: save, share, or publish what you learn—

save “**sessions**” to continue where you left off

export **graphics**

use/export to **Jupyter** environments

export to **plot.ly** (javascript)

export to **augmented reality**

learn how at glueviz.org.



glueviz.org

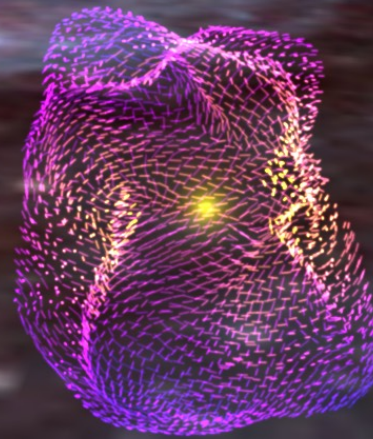
supported by



glue
solutions
inc.

GORDON AND BETTY
MOORE
FOUNDATION

Great...but what can I do with **glue**, in Astronomy?



The Magnetic Field of the Local Bubble, in 3D. O'Neill et al. 2023—image embargoed until AAS press conference 10:15 AM Wednesday



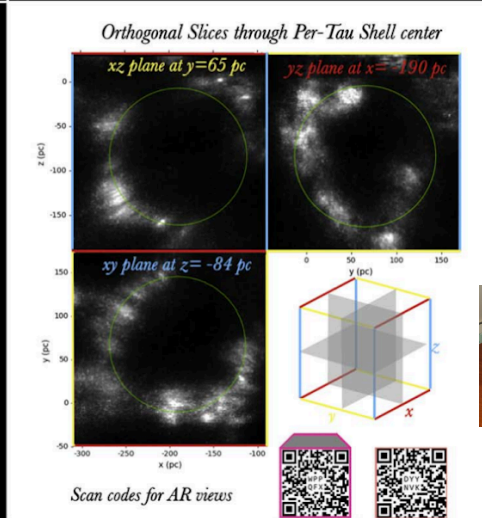
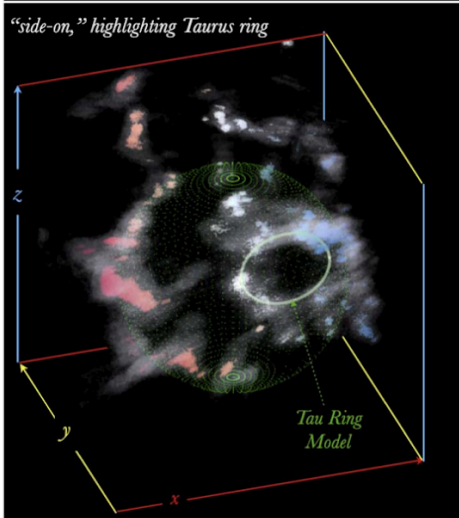
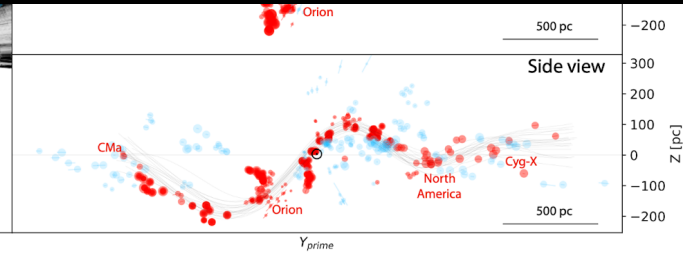
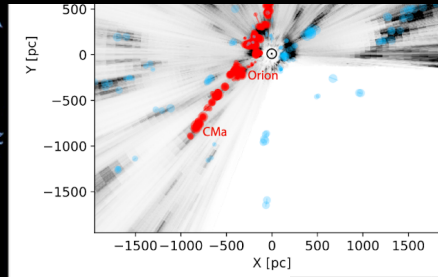
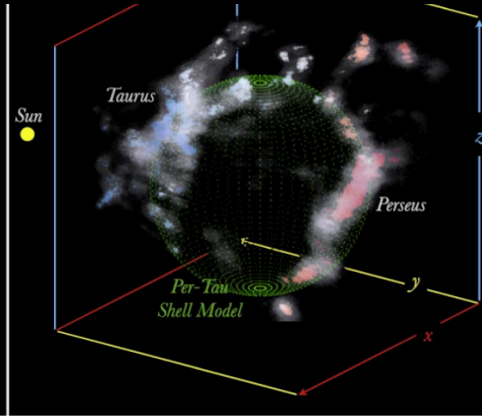
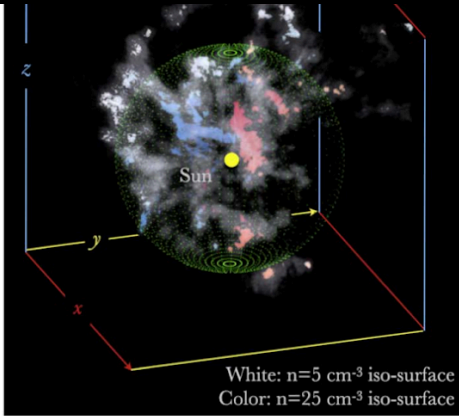
Top-down view

X_{prime}

End-or

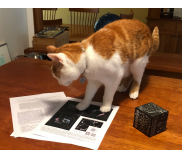


Great...but what can I do with **glue**, in Astronomy?

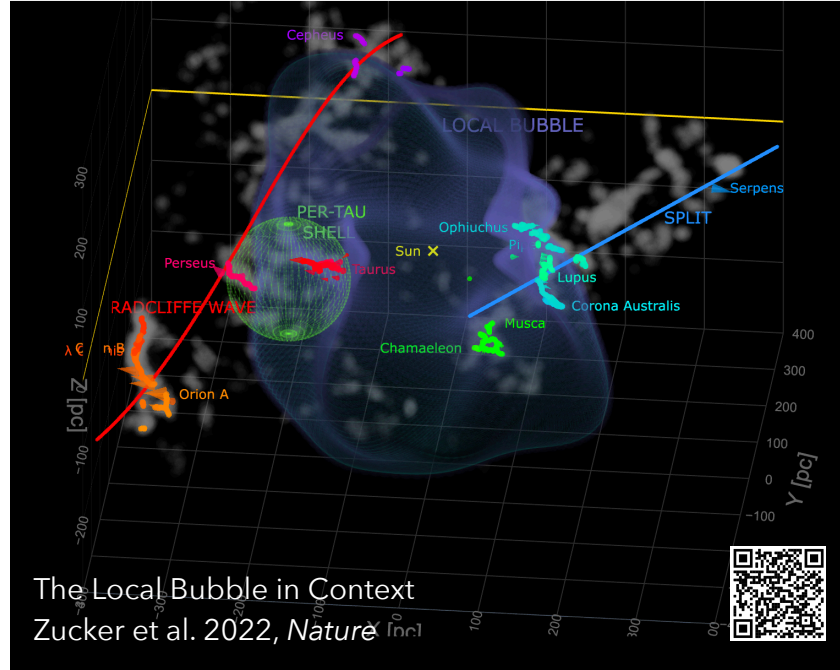


Scan this code for

a "handout"



←AR Codes



Data Collection

Tab 1

3D Scatter

3D Volume Rendering

What does the desktop glue interface look like?

Local Arm Fit (Reid+2016)
Major Cloud Catalog
Maser Catalog (Reid+2014,2016)
Sagittarius
Tenuis
Sun

Subsets

Plot Layers - 3D

Attribute: PRIMARY
Limits: 1 5
Color:

Plot Options - 3D Volume Rendering

x axis: Pixel Axis 2 [x]
min/max: 38.2241 1160.78
stretch: 1.00

y axis: Pixel Axis 1 [y]
min/max: 38.2241 1160.78
stretch: 1.00

z axis: Pixel Axis 0 [z]
min/max: 5.95402 193.046
stretch: 1.00

reference: Green 2019 3D Dust

WORLDWIDE TELESCOPE

plug-ins (user-defined formats, plots, layouts...)
web services (across domains)
command-line (built-in terminal, scriptable)

And how easy/hard is it to use?

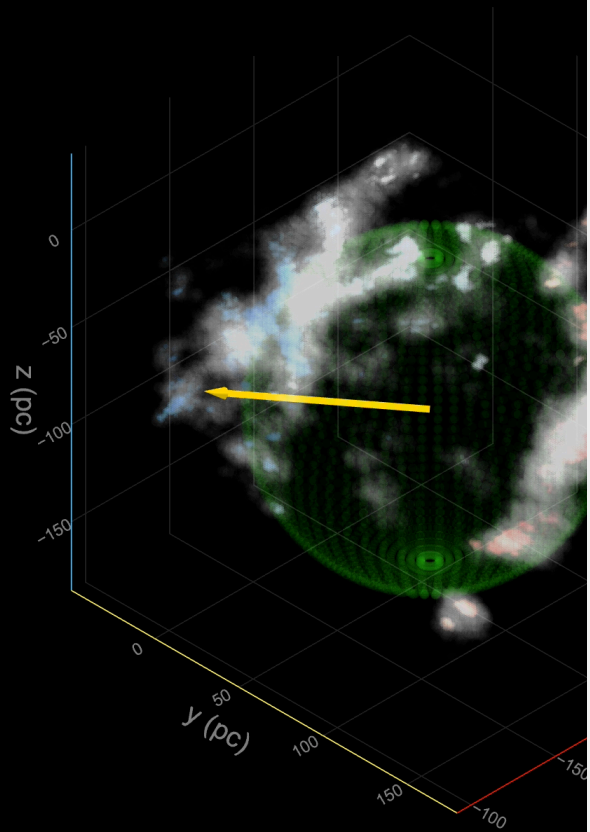
The image is a composite of three main elements:

- Top Left:** A screenshot of a 3D visualization software interface. The central window shows a 3D volume rendering of the Local Bubble, a region of interstellar space. The bubble is depicted as a glowing, irregularly shaped volume with a blue and purple color scheme. The interface includes a 'Data Collection' panel on the left with various data sources like 'Local_Area_FU_Resolved' and 'Local_Area_FU_Resolved'. Below that is a 'Plot Layers' panel with '3D Volume Rendering' selected. The 'Plot Options' panel at the bottom left shows settings for 'x axis', 'y axis', and 'z axis' with numerical values and 'switch' buttons. The bottom of the interface shows a standard operating system taskbar with various application icons.
- Top Right:** A snippet of a newspaper article from 'THE NEW YORK TIMES, TUESDAY, JANUARY 25, 2022'. The article is titled 'Local Bubble' and features a diagram of the bubble's structure. The diagram shows the Sun at the center, surrounded by the 'Orion Arm', 'Local Arm', and 'Local Bubble'. Other stars like 'Antares', 'Betelgeuse', 'Rigel', 'Deneb', 'Vega', 'Altair', and 'Proxima Centauri' are also labeled. The text discusses the discovery of the Local Bubble and its implications for the solar system's environment.
- Bottom:** A video call interface showing two participants. The top participant is a woman with glasses, identified as 'Alyssa Goodman'. The bottom participant is a man, identified as 'João Alves'. The interface includes a 'Mute' button, a 'Stop Video' button, and a 'Leave' button. The background of the video call is dark, and the participants are shown in a standard video call layout.

The Future



The Future of



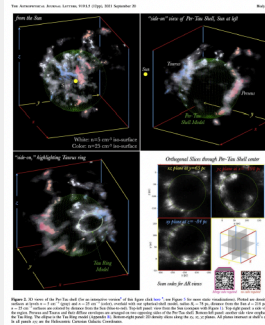
TINYURL.COM/UNIVERSE-I

Augmented Reality is here—in AAS Journals!

In 2021, the *Astrophysical Journal Letters* published the first **Augmented Reality (AR)** figure in an AAS Journal. The AR-enhanced figure (right) appears in a paper by [Bialy et al.](#) presenting the discovery of the Perseus-Taurus Supershell. An [AAS Nova](#) article describes the discovery and the technology in more detail.

Want to help the AAS bring you even-better AR experiences in the future?

Stop by the AAS booth (627) to help improve the AAS AR experience. If you participate in our user testing, you will leave with your very own augmented reality Merge Cube!



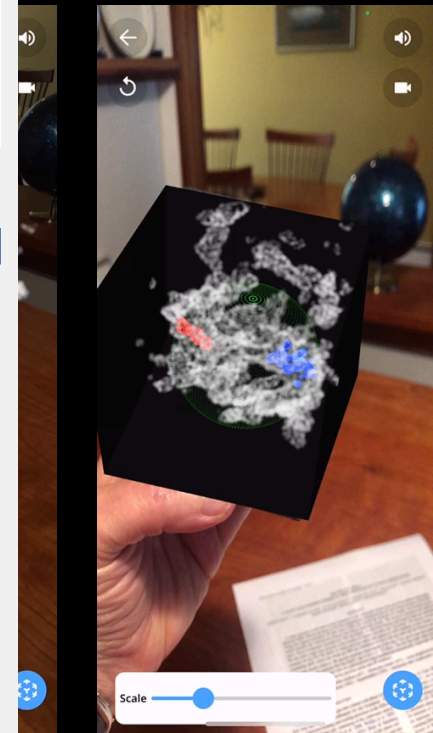
The video at tinyurl.com/Per-Tau-AR shows how it works.

WANT TO EXPLORE THE PERSEUS-TAURUS SUPERSHELL IN 3D?

IN YOUR BROWSER AT [TINYURL.COM/UNIVERSE-IN-MY-HAND](https://tinyurl.com/Universe-in-My-Hand) OR IN AUGMENTED REALITY (KEEP WATCHING)...

To try out an AR figure on your smartphone, scan one of the QR codes above.

The left-hand QR code does NOT require a "Merge Cube," and the right-hand code does. First-time users will be prompted to download a free app. The flat-screen interactive version of the figure, also showing the QR codes, is available at [TinyURL.com/Universe-in-My-Hand](https://tinyurl.com/Universe-in-My-Hand). *AR funded by NSF.*



Augmented Reality

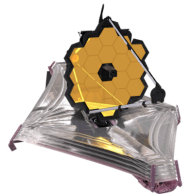
Next...

glue in the browser, for real.

glupyter (a.k.a. "glue jupyter")

"glupyter" is a union of [glue](#) and [Jupyter](#) software environments. We think it may well be the future of glue, or "glue-qt" as experts sometimes call the desktop app version of glue. This webpage, hosted openly and freely by [glue solutions, inc.](#), serves as a clearinghouse for current information about glupyter-related projects. Some of these projects are funded by government agencies (notably [NSF](#) and [NASA](#)), others by private foundations (e.g. [The Gordon and Betty Moore Foundation](#)), some as part of corporate collaborations (e.g. [Harvard+Google Data+Climate](#)), and some by open-source consulting work carried out by [glue solutions, inc.](#)

The [glue-jupyter GitHub repository](#) is fully open, and more detail can be found on this [Read the Docs page](#).



Quick insights for Images, Spectra

JDAViz

Includes: ImViz, CubeViz, SpecViz, MOSViz

Sponsor: NASA, James Webb Space Telescope

[Read more \(blog post at 10QViz.org\)...](#)

[GitHub](#)



Open-Source GIS Data Exploration

SAVE

Search-Analysis-Visualization-Environment

Sponsors: Harvard+Google Data+Climate

[Read more at Data+Climate site...](#)

[GitHub](#)



Data Science Education

Cosmic Data Stories

Sponsor: NASA, Science Activation Program (funded proposal)

[Read more at CosmicDS website...](#)

[GitHub](#)



bringing glue to JupyterLab

glupyter prototype

Sponsors: The Gordon and Betty Moore Foundation and the National Science Foundation

[Demo]

plug-ins galore!



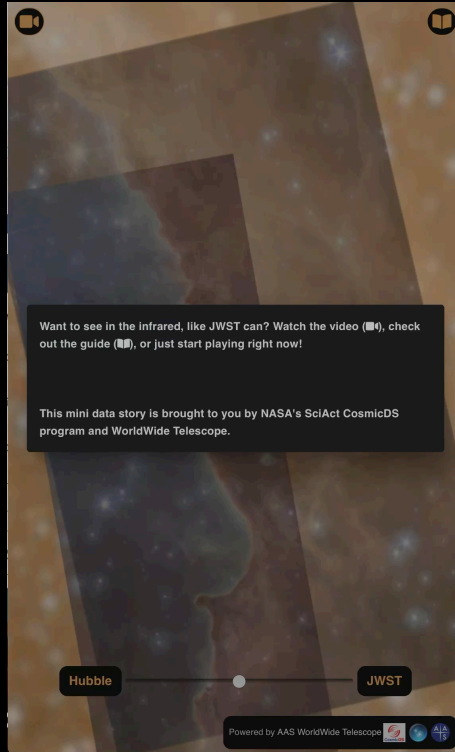
THE SOFTWARE STORY



Thanks to digital data projection, today's planetariums can be used as immersive visualization spaces in both educational and research contexts. And, thanks to modern open-source, modular, approaches to software development, new visualization tools can be built by mixing, matching, and adding to established older ones. In 2019, a group of visualization experts meeting in Dagstuhl, Germany decided to try integrating elements of several astronomy data visualization packages, with the aim of creating new, flexible, data exploration environments that would be useful in both research and educational contexts, on any size screen, including a planetarium dome. Since then, a series of gatherings and experiments at New York's Hayden Planetarium has led to the successful development of "plug-ins" that insert elements of one of three software packages ([glue](#), [WorldWide Telescope](#), [OpenSpace](#)) into the other two.

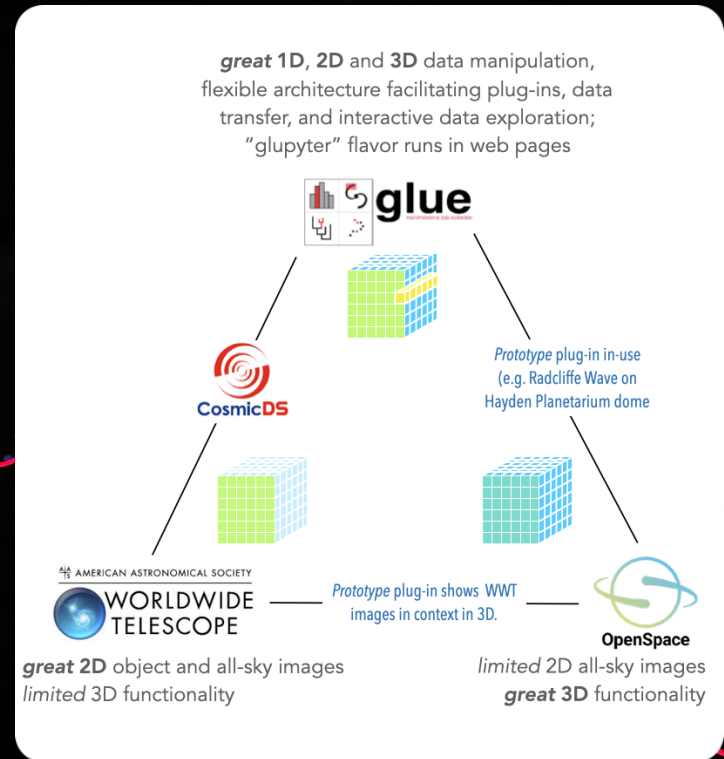


CosmicDS : Mini Data Stories



Look for Twitter "release"
of the tool this week!
EMBARGOED for now

MilkyWay3D.org

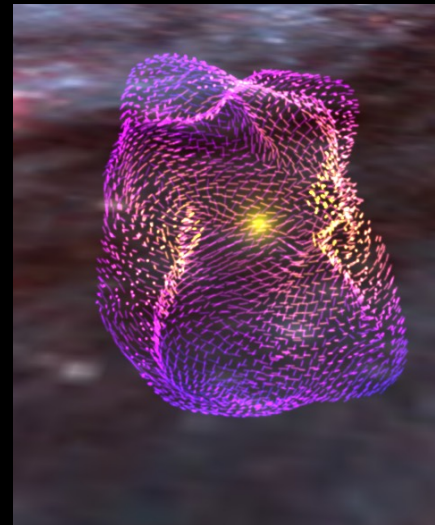


Ask about our NASA
Hyperwall demo(s)!

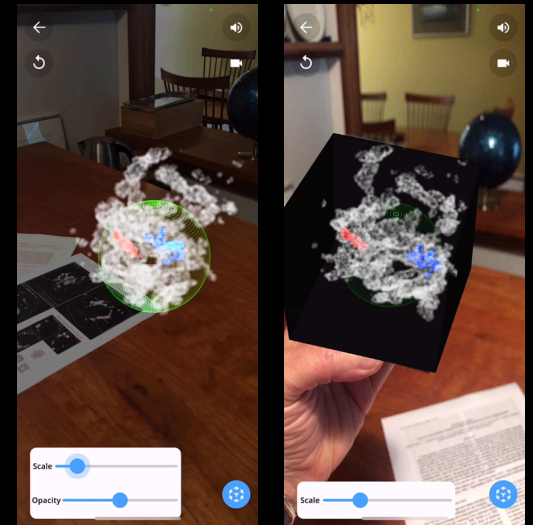
Exploratory Data Analysis and The Future, with glue

What is  **glue?**
multidimensional data exploration

glueviz.org



tinyurl.com/local-bubble-b
but **EMBARGOED** until Wednesday



gluesolutions.io/augmented-reality

Alyssa Goodman, Center for Astrophysics | Harvard & Smithsonian